An Assessment of Nuclear and Missile Developments in South Asia

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Abstract

Since conducting nuclear tests in 1998, both India and Pakistan have decided to build a "minimum nuclear deterrence", replacing the policy of "non-weaponized nuclear deterrence", followed since 1970s. Both countries appear to have accelerated their nuclear and missile programmes, particularly since 2001, while the international attention has been focused elsewhere such as Afghanistan and Iraq. Free from intensive international scrutiny, India and Pakistan continued to develop, test and deploy different types of ballistic missiles. The nuclear and missile developments in South Asia are gaining greater momentum rather than slowing down and India and Pakistan appear to be in danger of being trapped into a costly strategic arms race. This paper discusses various nuclear and missile developments in India and Pakistan and their technological capabilities. It also analyses the likely medium and long-term nuclear and missile developments or trends in South Asia and their implications for regional and global security, particularly from the view of nuclear and missile non-proliferation.

1. Introduction

Since India and Pakistan conducted a series of nuclear tests in 1998, both countries have embarked on a policy of 'minimum nuclear-deterrent' and develop a series of ballistic missiles to implement this policy. This paper analyses nuclear and missile developments in India and Pakistan. It also compares strategic technological capabilities between the two countries and discusses likely developments or trends in the short, medium, and long-term. Although a number of studies have highlighted various nuclear and missile technology developments in India and Pakistan, there are very few studies that try to make an in depth comparison of strategic technological capabilities between the two countries and their likely impact on future developments. This paper also draws some conclusions about the implications of the nuclear and missile build up to the regional and global security, particularly from the view of non-proliferation.

2. Diplomatic, Military and Policy Developments

Following their nuclear tests in 1998, both India and Pakistan announced their intention to move towards the next stage of deploying nuclear forces. In the winter of 1998-1999 Pakistan launched a military operation (involving militants supported by armed forces) to occupy and control territories around Kargil on the Indian side of the Line of Control in Kashmir. However, facing strong counter military offensive from India and international criticism Pakistan was forced to withdraw. It is likely that Pakistan was sure that India would not launch counter-military action in the face of potential use of nuclear weapons by Pakistan. The Kargil conflict has exposed the limitations of the possession of nuclear weapons and demonstrated the importance of conventional forces. Subsequently, India released its draft nuclear doctrine on 17 August 1999 which advocated “minimum but credible deterrence” through the deployment of a nuclear triad, that is land and sea based missiles and air-delivered weapons. It was estimated that India would be deploying 350-400 nuclear weapons. The draft doctrine stated that India’s nuclear weapons are not “country specific” and the survivability of these forces “will be enhanced by a combination of multiple redundant systems, mobility, dispersion, and deception.” By stating that its nuclear weapons deployment is not ‘country-specific’ India has made it clear that its nuclear weapons would be aimed not only at Pakistan but also at its bigger rival China. However, India’s draft nuclear doctrine pledged to pursue policies of “no-first use” and never to use nuclear weapons against a non-nuclear state. India also reiterated that it remained in favour of complete disarmament, despite its decision to deploy nuclear weapons. Pakistan responded by declaring its own policy towards nuclear deployment. Pakistan’s stated aims of its ‘minimum nuclear deterrence’ are two fold -- first, to achieve some parity with India’s nuclear capability; and second, to deter India’s superior conventional forces. Subsequently, it announced the establishment of formal nuclear command structure.

In December 2001, armed militants attacked Indian Parliament in New Delhi. India accused Pakistan for the attack and withdrew its diplomats from Pakistan and moved a large number of troops along the border and Pakistan responded by moving its troops to the border. The military and the diplomatic tensions between the two continued until early 2003 and India announced the establishment of a formal nuclear command structure on 04 January 2003. It also announced its intention to test its Agni III missile with a range of 3000 km during 2003, which is likely to create concerns in China, as it is capable of striking targets deep into that country (*The Times of India*, 7 February 2003). Furthermore, India refused to accept the International Code of Conduct Against Ballistic Missile Proliferation (ICOC) – an initiative to overcome the limitations of the Missile Technology Control Regime (MTCR), against ballistic missile proliferation and appears to be encouraging its industry to export missiles and related components (*The Hindu*, 15 November 2002 and 06 May 2003). Since the nuclear tests in 1998, although both countries publicly stated that they did not intend to start an arms race, they went on to develop and launch number of missiles as part of their nuclear weapons deployment and integrated some of these systems with their military forces. These developments are discussed in the following sections.

3. Nuclear Weapons: Developments and Capabilities

Since 1945, nuclear technology has become increasingly sophisticated due to technological change and developments in countries such as the US and the former Soviet Union. By the late 1970s, the nuclear technology has almost fully matured and the rate of design innovations and truly new concepts slowed significantly. As a result late comers such as Pakistan benefited and they need not to go thorough the phase of developing a strong basic research base to successfully construct nuclear weapons. In the context of India and Pakistan it is important to take this into account when analysing the balance of strategic technological capabilities between the two countries. A strong basic research base, and extensive nuclear infrastructure such as mining of uranium, enrichment of uranium metal in the fissile isotope U-235, production and extraction of plutonium, production of tritium, and separation of deuterium and Li-6 to build thermonuclear weapons could contribute to achieving a high level of capability. However, it is quite possible to build an intermediate level nuclear capability with limited infrastructure and highly focused resources. In other words, the country enjoying a superior nuclear technological capability is unlikely to maintain that level of superiority over its less developed rival, as there are strong limitations to new innovations. This is important to keep in mind when comparing the nuclear capabilities between India and Pakistan. India started its nuclear programme at least 15 years earlier than Pakistan. Whether this advantage did help India to command a relative superiority over the late comer Pakistan; and if it did, whether India will be able to maintain this superiority in the future are interesting questions which need proper investigation.

From the 1998 nuclear tests by India and Pakistan, despite the claims and counter claims over the types and yields of weapons tested, it is evident that both countries have acquired significant nuclear weapons capabilities. India and Pakistan have followed different routes to produce weapon-grade nuclear materials. India followed the plutonium route; that is, by reprocessing spent fuel from nuclear reactors it produced plutonium stockpile to develop nuclear weapons. On the other hand, Pakistan primarily followed the method of uranium enrichment and produced highly enriched uranium to build its nuclear weapons. However, recent studies suggest that Pakistan is also developing the capability to produce weapon-grade plutonium (see Albright, 2000; Cordesman, 2002). While India has "developed a massive indigenous civil and military" nuclear infrastructure (Cordesman, 2002), "Pakistan lacks an extensive civil nuclear power infrastructure, and its weapons programme is not as broad as India's" (FAS Website). Unlike India's nuclear programme, which includes a significant civil nuclear energy component, almost the entire nuclear programme in Pakistan is focused on weapons applications. In other words, it is generally believed that Pakistan has been utilising its nuclear programme primarily (or solely) to produce fissile material which could be used to make nuclear weapons (see Albright, 2000). On the other hand, a number of studies have concluded that India has not been employing the whole of its available capacity to produce weapon-grade plutonium (e.g. Albright, 2000, RAND 2001). Although this appears to be a deliberate policy on the part of India, the impact of this factor on the nuclear balance between India and Pakistan needs to be taken into account.

One of the major studies about nuclear weapons in South Asia was done by David Albright at the Institute for Science and International Security (ISIS) in the US. This has been widely referred to by a number of other authors. Therefore, it merits a brief discussion here. Using a "more sophisticated method" than the one he employed in his past studies (i.e. using Crystal Ball software and 'Monte Carlo' approach), Albright calculated the size of India's stock of weapon-grade plutonium and Pakistan's inventory of separated weapon-grade uranium and weapon-grade plutonium. He has calculated India's inventory by "estimating total production of weapon-grade plutonium in the Cirus, Dhruva, and power reactors and by subtracting drawdowns from nuclear testing, process losses, and civil uses of the weapon grade plutonium" (Albright, 2000). He employed two estimates: (i) the median value (the value midway between the smallest and largest value, which was about 310 kilograms of weapons grade plutonium; and the range of values between 5th and 95th percentiles, which are 240 Kgs to 395 Kgs respectively. In other words, he claimed that it was 90 per cent certain that the true value of (India's inventory) at the end of 1999 was between 240 and 395 Kgs, where the median value was about 310 Kgs. He employed the measure of 4.5 Kgs plutonium per nuclear weapon to calculate total number of nuclear weapons that India could have made using the available fissile material. Accordingly, the median estimate was about 65 weapons and the 5th and 95th percentiles were 45 and 95 weapons respectively. Albright estimated that Cirus and Dhuruva together produced 410 Kgs of weapon-grade plutonium, the power reactors produced about 25 Kgs, and the drawdown was about 125 Kgs. In his calculation Albright ignored any highly enriched uranium (HEU) produced by India as insignificant.

In the case of Pakistan, he estimated the inventory of weapon-grade uranium by taking into account factors such as enrichment capacity, the feed stock into the enrichment plant, and the amount of LEU produced in Pakistan during the 1990s. Then, he subtracted the drawdowns from the 1998 nuclear tests. The estimated median value of Pakistan's inventory was 690 Kgs, and the 5th and 95th percentiles were 585 and 800 Kgs respectively. The number of nuclear weapons Pakistan could have made from its weapon-grade uranium stock was estimated by employing a measure of 18 Kgs of weapon-grade uranium per weapon. Accordingly, the median value was 39 weapons, and the 5th and 95th percentiles were 30 and 52 weapons respectively. Furthermore, Albright estimated that Pakistan could build a single nuclear weapon using the small amount of weapon-grade plutonium produced by one of its reactors.

<u>Table 1: Estimates of Nuclear Capabilities in India and Pakistan</u>

Type of Material/Estimate	India	Pakistan
<u>I. Weapon-grade Plutonium</u>		
Median (Kg)	310	5.5.
5th and 95th Percentiles (Kgs)	240-395	1.7 - 13
A. II. Weapon-grade Uranium		
Median (Kg)	Insignificant	690
5th and 95th Percentiles (Kgs)	Insignificant	585 - 800
III. Nuclear Weapon Equivalent of Fissile Material Stockpile		
Median (Kg)	65	39
5th and 95th Percentiles (Kgs)	45 - 95	30 – 52
IV. Civil Plutonium Stockpile		
1. Safeguarded by the IAEA:		
Separated	25	0
Unseparated	4,100	600 (Rounded figure)
2. Unsafeguarded:		
Separated	800	0
Unseparated	3,400	0
Total Civil Plutonium	8,300	600 (Rounded figure)
3. Weapon-Equivalent	1,400	75

<u>Source:</u> David Albright (October 11, 2000), *India's and Pakistan's Fissile Material and Nuclear Weapons Inventories, end of 1999.*

Using similar methods of calculation, Albright has also estimated the potential nuclear weapons capability of India and Pakistan, if they had decided to use the reactor-grade (civil) plutonium. Using the measure of 8Kg of civil plutonium per weapon, he estimated that India could have produced 8300 Kgs of civil plutonium which is equivalent to 1040 weapons and Pakistan could have produced 600 Kgs (of reactor grade plutonium) that is equivalent to 75 weapons. However, he acknowledged that “almost all of this civil plutonium is in spent fuel, and thus not suitable for use in nuclear weapons” (Albright, 2000). Various estimates of nuclear capabilities of India and Pakistan by Albright are illustrated in Table 1.

In 1997, A. H. Nayyar, A.H. Toor, and Zia Mian attempted to estimate “the amount of weapons-grade plutonium that could have been produced from unsafeguarded power reactors in India, if these reactors were operated deliberately for this purpose” (Nayyar et al., 1997, p. 190). According to them, “India could have used its power reactors to produce 1,450 kg of WGPu beyond the estimated 425 kg [by Albright and others] from research reactors” (Nayyar et al., 1997, p. 197). However, they also acknowledged that there was no evidence that India had used power reactors to produce WGPu. They argued that if India wanted to use its power reactors to produce WGPu, the only constraint it faced was the processing capacity. They have concluded that once Kalpakkam II reprocessing plant starts operating, India could “extract about 1,500 kg WGPu from the accumulated 1,579 tons of as yet un-processed spent fuel in less than two years” (Nayyar et al., 1997, p. 196). They reasoned that India was likely to have built up its fissile material stock file by reprocessing spent fuel from the unsafeguarded power reactors mainly to produce high yield weapons.

In the case of Pakistan, the authors believed that “rather than closing down the facilities for uranium enrichment” completely, as claimed by the Pakistan government in 1990-1991, it continued to operate them at “a much lower (than weapon-grade) level of enrichment” mode (Nayyar et al, 1997, p. 198). It was estimated that total Pakistani enrichment capacity was between 9,000 SWU’s (kilogram Separative Work Units per year, which has dimensions of kg/year) and 15,000 SWUs (for Kahuta facility). With this capacity, between 1991 and 1995, Pakistan was estimated to have produced between 6 and 22 tones of 5-3 per cent enrichment uranium (or lesser quantities of 20 per cent uranium). In other words, the authors argued that Pakistan was capable of producing about 200 kg of 90 per cent uranium – "roughly double the quantity of weapons-grade uranium estimated by Albright et al" within a period between few months and a year (Nayyar et al, 1997, p. 200). This could have substantially increased its existing HEU stocks. Table-2 shows the estimates by Nayyar et al.

Table-2: Estimates of LEU Stockpile Accumulate by Pakistan between 1991 and 1995 and Time Required to Produce 200Kg of WGPu from LEU Stockpile

Level of Enrichment of LEU (%)	Mass of Product (kg) for 9,000 SWUs	Mass of Product (kg) for 15,000 SWUs	Time in Weeks for 9,000 SWUs to Produce 200 kg of Wgpu from LEU Stockpile	Time in Weeks for 15,000 SWUs to Produce 200 kg of Wgpu from LEU Stockpile
3	13, 123	21, 871	49	26
5	6, 245	10, 407	33	17

Source: Nayyar et al. (1997), "Fissile Material Production Potential in South Asia," *Science and Global Security*, vol. 6, p. 201.

If these estimates by Nayyar et al (that Pakistan was in a position after 1995 to produce 200 Kgs of 90 per cent uranium in about few months to a year period) are nearly accurate, it is likely that Pakistan could have produced over 400 Kgs of 90 per cent uranium by 2001. Because, it is quite likely that Pakistan went ahead to utilise its full capacity to produce 90 per cent uranium since its nuclear tests in 1998. That means, while India has been following a 'restrained' and 'limited' approach towards building fissile material stockpile and nuclear weapons, Pakistan has been utilising its entire capacity to build up not only fissile material stockpile but also building of nuclear weapons.

In 2001, the US Department of Defence estimated that India could "deploy a few nuclear weapons within a few days to a week" (Cardesman, 2002, p. 24). It concluded that although India is capable of producing all components required for plutonium-based nuclear weapons, foreign equipment would help it to develop more sophisticated weapons. In the case of Pakistan, it concluded that although it “has a well developed nuclear infrastructure, including facilities for uranium conversion and enrichment and the infrastructure to produce nuclear weapons,” it “has less of a military production infrastructure than rival India, and thus will be forced to rely on outside support for its efforts for several years” (Cordesman, 2002, p. 36). The general perception is that China has been the main foreign source of technology assistance for Pakistan’s nuclear programme. Until now, China has played a major role in assisting Pakistan’s nuclear programme. China’s assistance included a 25-kiloton warhead design, significant quantity of HEU for building few weapons, and 5,000 custom-made ring magnets for high speed centrifuges, (Cordesman, 2002, p. 44). According to the Carnegie Endowment reports, China assisted Pakistan to complete its 40-Mwt heavy water research reactor at Khushab in 1996. It appears China also has been assisting Pakistan to build a facility linked to Khushab reactor, either a fuel fabrication plant or a plutonium separation (reprocessing) plant. Pakistan did not have a fuel fabrication facility to manufacture fuel for the new reactor (Cordesman, 2002, p. 44). It is further believed that China might have supplied the design for a small tritium (neutron) initiator (which is located at the centre of the weapon grade uranium core of a nuclear bomb) that starts the fission chain reaction (Albright and Hibbs, 1992). As China factor has been very important in Pakistan’s nuclear capability building over the years, it is imperative that it is taken into account in any analysis of nuclear balance between India and Pakistan.

Table 3 illustrates capabilities of India and Pakistan in thirteen different areas of nuclear technology, identified by the US Department of Defense (1996). The author has updated capabilities of India and Pakistan summarised in DoD’s (1996) ‘nuclear weapons foreign technology assessment’ by taking into account various developments since 1996. The DoD employed a four-point scale – (i) limited capability; (ii) some capability; (iii) sufficient level; and (iv) exceeding sufficient level; to assess technological capabilities of different countries. ‘Sufficient Level’ is defined as the capability required “to produce entry-level WMD, delivery systems, or other hardware or software useful in WMD development, integration or use” (DoD, 1996, p. II-B-1).

Table 3: Comparison of Nuclear Technological Capabilities between India and Pakistan

Technology/Weapon Systems	India	Pakistan
Enrichment Feed-stocks Production	xx	xxx
Uranium Enrichment Processes	Not Known	xxx
Nuclear Fission Reactors	xxxx	xx
Plutonium Extraction (Reprocessing)	xxx	x
Lithium Production	Not Known	Not Known
Nuclear Weapons Design and Development	xxxx	xxxx
Safing, Arming, Fusing, and Firing	xxx	xxx
Radiological Weapons	xx	x
Manufacturing of Nuclear Components	xxx	xxx
Nuclear Weapons Development Testing	xxx	xxx
Nuclear Weapons Custody, Transport and Control	xxx	xxx
Heavy Water Production	xxxx	x
Tritium Production	xxxx	x

Source: The table was prepared by the author using ‘Nuclear weapons foreign technology assessment summary’ in US Department of Defense, *Militarily Critical Technologies List – Part II: Weapons of Mass Destruction Technologies*, 1996. But the author updated this summary taking into account various developments since 1996.

Notes:
x – Limited Capability; xx – Some Capability; xxx – Sufficient Level of Capability; xxxx – Exceeding Sufficient Level of Capability

It is evident from Table 3 that Pakistan is not far behind India’s nuclear capability, particularly in areas such as fissile material production, design and development of nuclear weapons. Pakistan has developed sufficient capability or more than sufficient capability in enrichment feed-stock production, uranium enrichment processes, nuclear weapons design and development, safing, arming, fusing and firing, and nuclear weapons development testing. While India appears to have superiority in heavy water production, tritium production and plutonium extraction, Pakistan has a clear superiority in uranium enrichment processes. India’s advantage in plutonium and tritium production gives it an edge over Pakistan in developing high yield weapons. However, Table 3 suggests that

Pakistan has developed a comparable nuclear weapons capability over the years. Although India has developed strong capabilities by the early 1970s when Pakistan had almost no capability, the latter appears to have established very significant level of over all capability by the late 1990s (as shown by Table 3). Although there is no clear evidence about the capability of Pakistan to produce tritium, it is likely that it has established a small facility for tritium purification by using the technology (plans and the know-how) obtained clandestinely from Germany in 1987 (Albright and Hibbs, 1992).

The major aspects of nuclear programmes in India and Pakistan, particularly the potential nuclear weapons capabilities can be summarised as following:

(i) India's civil and military nuclear activities are extensive and much broader than Pakistan's programme;

(ii) India's nuclear weapons programme is 'limited' and it does not utilise the entire capability available to produce weapon-grade material;

(iii) Pakistan's nuclear programme is 'bomb-centred', that is, it makes weapons grade material using almost the entire nuclear infrastructure and uses them to build nuclear weapons;

(iv) Pakistan either possesses or likely to possess in short to medium term sufficient number of nuclear weapons to match India's capability;

(v) Pakistan has received and is likely to receive in future significant technology assistance from China.

(vi) Both India and Pakistan have been able to achieve a high degree of self-reliance in producing weapon-grade materials and building nuclear weapons.

(vii) Although India appears to have a larger stockpile of weapon-grade material and also has greater capability to produce more weapon-grade materials than Pakistan, this advantage or technological superiority is likely to disappear in the medium to long-term.

4. Ballistic Missiles: Developments and Capabilities

Both India and Pakistan appear to have chosen ballistic missiles as main delivery systems for their nuclear weapons in the medium and long-term. Although both countries do have ballistic missile systems capable of launching nuclear weapons, their missile programmes are yet to mature fully. Unlike the case of producing weapon-grade materials and nuclear weapons, the gap in missile capabilities between the two countries appears to be more clear and significant. Missile systems involve a large number of critical technologies and the rate of technological change is still relatively high, and therefore 'catching up' by a late comer without foreign assistance is likely to be more difficult. In the context of India and Pakistan, this is more likely to decide the balance of strategic capabilities between the two countries in the medium and long-term than the capability to build nuclear weapons. Unlike the case of building nuclear weapons where both India and Pakistan have already entered the production-mode, their missile programmes still appear to be largely in the development phase. Both countries are developing different types of missiles based on solid and liquid propulsion systems. Tables 4 and 5 illustrate the main characteristics of missiles developed by India and Pakistan respectively.

The Defence Research and Development Organisation (DRDO) under the Ministry of Defence (MOD) runs India's missile programme. At present, the programme involves mainly developing two families of missiles – Prithvi and Agni. India has either already started producing or in the process of producing different versions of short range Prithvi missiles for different users such as Army, Air Force and Navy. Because of historic reasons these are single stage liquid systems which have seen incremental and cumulative improvements over the years through large number of test launches. Prithvi is a single stage liquid fuel system – red fuming nitric acid oxidiser with a 50/50 mix of Xylidiene and triethylamine fuel. It is not an efficient system and it is difficult to handle, as it requires loading prior to the launch of the missile. This imposes certain operational constraints in battlefield conditions. For strategic and tactical reasons such as not to lower the nuclear threshold, the shorter range Prithvi-Is and certain Navy-versions are likely to be used only for carrying conventional warheads. Other versions are likely to be deployed to carry nuclear warheads.

Table 4: Ballistic Missiles Developed by India

Name	Type	Propulsion	Warhead/ Range	Status
Prithvi I (SS150)	SRBM	Single stage Liquid system	1000 kg/150Km	Production Completed/Stopped
Prithvi II (SS250)	SRBM	Single stage Liquid system	500-1000 kg/250 km	In Production
Dhanush	SLBM	Liquid system	500 kg/250 km (achieved 150 km range during test)	Tested successfully on 21 September 2001. In Development
Agni (Technology Demonstrator)	IRBM	Two stage – Solid + Liquid	1000 kg/2000 km (Actual range achieved was 1450 km)	Development Programme completed after three test flights
Agni I	MRBM	Single stage Solid system	1000 kg/700-1000 km	Tested successfully on 25 January 2002 (700 km achieved) and on 09 January 2003. Development/Operational
Agni II	IRBM	Two stage – Solid + Solid	1000 kg / 2500-3000 km	Tested successfully on 11 April 1999 and 17 January 2001 (Over 2100 km achieved) Operational and entered full-scale production in early 2002.
Agni III	IRBM	Two stage – Solid + Liquid	1000kg/3500-4000 km	Under Development. First Test Flight Expected in 2003
Surya	ICBM	Two stage solid system	1000 kg/8000 km	Likely to be developed. India has the capability to develop an ICBM within 15 to 24 months from the day of decision.

Source: Compiled by the Author

Initially, for historic reasons, Agni was developed by combining the liquid stage of Prithvi and the first solid stage of SLV-3 (from civil space programme). However, by the late 1990s, it has been optimised and standardised as single and two stage solid systems for medium and intermediate ranges respectively. It is quite likely that India may develop a navy-version of Agni I and II in the near future. Also, India has the capability and the resources to develop an ICBM within a short time (between 15 to 24 months), if it decides to do so. Although the missile programme appears to have been initiated without clear long-term vision, events within the region and outside the region appear to have shaped it into a strategically coherent and technologically sound and meaningful programme. This is clear from the way Agni was transformed into a solid-based system from a combined liquid and solid system. Solid propellant missiles are stable, easily storable, and easy to handle before launching. Unlike liquid systems, they do not need fuel loading before the launch, making it more efficient and less vulnerable to exposure. Although liquid based systems could be relatively easy to manoeuvre on-flight and they could be more accurate than the solid systems, they are very complex and inefficient because they are difficult to handle, involve longer time for preparation, and require larger launch support infrastructure. Furthermore, liquid engines incorporate large number of components, making it more complex for operation.

India's missile programme is highly indigenous with relatively small degree of dependence on foreign imports, particularly in the area of high precision materials and micro electronic components. If the civil space programme is taken into account, India has already established a world class capability in solid propulsion technology, guidance systems including on-board micro-processors and software, and re-entry technology. India has capacity to produce over 600 tonnes of solid propellants per annum from various facilities. Indian Industry has learned over the years to optimise fabrication of hardware such as rocket motor casings from maraging steel, fabrication of components from advanced materials such as titanium alloy, solid and liquid propellants such as HTPB, UDMH, MMH, ammonium perchlorate, and nitrogen tetroxide. It also has developed a large network of suppliers and sub-contractors in the industry. India's capability in guidance system has grown significantly in the 1990s. This is clearly reflected by the joint development of BrahMos supersonic cruise missiles by India and Russia. These missiles incorporate Russian liquid fuel Ramjet propulsion system and Indian guidance system. They are expected to be superior to the US Tomahawk and Russian Moskit (*Telegraph India*, 06 February 2002). One of the prototype Brahmos cruise missiles was tested on 12 February 2003. The fact that Russia preferred to develop these sophisticated and advanced missiles jointly with India has demonstrated that India has established a world-class capability in guidance systems.

<u>Table 5: Ballistic Missiles Developed/Acquired by Pakistan</u>

Name	Type	Propulsion	Warhead/ Range	Status
Haft I (Based on French sounding rocket technology)	SRBM	Single stage Solid system	500 kg/60-80 km 350 kg/-100 km	Tested/Not produced
M-11 (Acquired from China)	SRBM	Single stage Solid system	700 kg/300 Km	Acquired about 30 missiles from China in 1992
Haft II (Based on French Sounding rocket technology/Haft I)	SRBM	Two stage Solid system	500 kg/280 km 300 kg/300 km	Small scale production from 1996. Improved version tested on 28 June 2002.
Haft III (Based on Chinese M-11/Haft I)	SRBM	Two stage Solid system	500kg/550 km	Tested on 26 June 2002. In Development
Ghauri I (Based on North Korean No-dong)	MRBM	Single stage Liquid system	500-750 kg/1300-1500 km (Achieved 1100 km range in test)	Tested on 06 April 1998 and on 24 May 2002. Believed to have deployed 5-10 missiles with 47th artillery brigade.
Ghauri II (Based on North Korean No-dong)	IRBM	Single stage Liquid system	1000kg/2000-2300 km	Under Development
Ghauri III (Based on North Korean Taepo-dong)	IRBM	Two stage Liquid system	1000 kg/3000 km	Under Development
Shaheen I (Based on Chinese M-9 with modified M11 TEL launcher)	SRBM	Single stage Solid System	1000 kg/750 km	Tested in April 1999, February 2000, and October 2002.
Shaheen II (Pak-version of Chinese M18 or Improved version of M 9)	IRBM	Two stage Solid System	1000 kg/2000 km	Under Development

<u>Source:</u> Compiled by the Author

Overall, India has established a very high level of indigenous capabilities in building both liquid and solid propulsion missile systems. India's capabilities particularly in solid rocket motor technology is comparable to the best in the world. Over the years, the industry has developed a high level of capabilities in producing advanced materials such as maraging steel, titanium alloy, different chemicals for solid and liquid propellants, certain composite materials, and various hardware and software for inertial navigation systems including rate integrated gyros, dynamically tuned gyros, and servo accelerometers, and on-board computers.

Pakistan's missile programme started with sounding rocket technology imported from France. This sounding rocket technology and associated fabrication facilities were used to develop short range missiles Haft I and Haft II. However, Pakistan appears to have made little headway in developing an indigenous programme from Haft I and II. It acquired M-11 SRBMs from China in the early 1990s and since then Pakistan has been developing mainly two families of missiles: (i) Shaheen (SRBM and IRBM) based on Chinese M-9/M-11 solid propulsion technology; and (ii) Ghauri (SRBM and IRBM) based on North Korean No-dong 1 and Taepo-dong 1 liquid propulsion systems. If Pakistan acquires the technology of Taepo-dong 1 for its Ghauri II and III, it will be able to employ the warhead spin-up technology (re-entry), which will considerably increase the accuracy of warhead. There appears to be some confusion over Haft III and Shaheen/Shaheen I among Western analysts. Whether they are same or different missile systems does not make much difference, as they are SRBMs and both are largely based on Chinese M-9 or M-11 solid propulsion systems. The Shaheen project is controlled by the National Defence Complex (NDC), a subsidiary of the Pakistan Atomic Energy Commission (PAEC), which used the facilities of Space and Upper Atmosphere Research Commission (SUPARCO). The A. Q. Khan Research Laboratories, which also controls the nuclear weapon programme, runs the Ghauri project. There appears to be a strong bureaucratic rivalry among these agencies that may hinder close co-ordination between their development projects (Siddiqa-Agha, 1999, pp. 355-56).

Pakistan has made significant progress since 1996 in developing short and medium range ballistic missiles, mainly because of foreign technology assistance received from China and North Korea. Particularly, after North Korea tested the No-dong missile in 1993, Pakistan appears to have established a collaborative relationship with that country with the aim of procuring complete missile systems and the production technology. It appears that Pakistani observers were present when the missile was first tested in 1993 (Bermudez, 1999, p. 21). North Korea took considerable time to fully develop various sub-systems of No-dong. This involved development activities such as scaling up the Isayev 9D21 engine and improving the guidance system, which were used in its earlier missiles – Hwasong 5 and 6. By 1999, Korea was estimated to have produced between 75 and 150 No-dong missiles. Of these, it was believed to have sold between 24 and 50 missiles to other countries including Pakistan. It is also believed that North Korea has agreed to provide Pakistan "key components from either the No-dong or Taepo-dong programmes, about 12 to 25 No-dong missiles, and at least one TEL or MEL". Most of these items were supplied by the Changgwang Sinyong Corporation to Khan Research Laboratories at Kahuta in 1996 (Bermudez, 1999, p. 24). The first test flight of Ghauri in April 1998 was "in fact, a DPRK-produced No-dong launched from a MEL," which appears to have been conducted by Pakistan in the presence of North Korean observers (Bermudez, 1999, p. 24).

Again, it appears that Ghauri-II that was launched in April 1999 was also a North Korean produced No-dong. These two tests were considered as the second and fourth tests of No-dong missiles system respectively after the first North Korean test launch in 1993. Iran's Shehab-III test flight in July 1998 was believed to be the third test of No-dong (Bermudez, 1999, pp. 24-25). Iran's missile collaboration with North Korea seems to be much closer and longer than Pakistan's relationship with North Korea. However, since the early 1990s, Pakistan's missile technology relationship with North Korea appears to have been growing stronger. This is demonstrated by the presence of Pakistani observers during the Taepo-dong 1 SLV launch in 1998. It is evident that by the late 1990s, North Korea has developed the Taepo-dong 1-- a two-stage ballistic missile based on liquid propulsion. It is not a coincidence that at the same time Pakistan has announced that it started developing an IRBM. It is quite likely that Pakistan could acquire Taepo-dong I or II from North Korea and launch it as an indigenously developed missile (Ghauri III). In the present international political climate where North Korea is under significant pressure from an aggressive US administration and also due to its dependency on international aid to relieve domestic hardships, it may feel constrained to conduct a series of Taepo-dong test flights. Therefore, it may decide to help and use Pakistan to carry out test launchings of Taepo-dong missiles, which serves the objectives of both North Korea and Pakistan. Unlike Iran, North Korea's another missile-collaborator, which faces strong American and international pressure, Pakistan is likely to get away with international pressure or reaction without serious consequences, if it decides to test launch Taepo-dong missiles as indigenously developed Ghauri IIIs. However it may choose to test launch these missiles in a conducive international environment, for example, after India conducts its next Agni test. India's missile programme provides Pakistan the legitimacy it requires for conducting test launch and its closeness with the US since the Afghan War is likely to help overcome any international reaction without serious impact.

Therefore, it is likely that Pakistan will be able to acquire intermediate and long range ballistic missiles capabilities within the next five years. In the medium and long term, Pakistan is likely to create local capabilities to produce a number of hardware required, using imported know-how and technology from different sources such as China, North Korea, and European countries. Once it masters the Korean missile systems, it may find it relatively easy to incrementally improve critical subsystems such as guidance systems using advanced components, acquiring from various sources. For example, it could relatively easily improve the guidance system using Global Positioning System (GPS) and/ or stellar navigation. The GPSs are readily available, as they are increasingly used for civil applications. Already, over 300 versions of GPS receivers are sold throughout the world (Wick et al., 1994).

Apart from the nuclear and missile complex, Pakistan has a sizeable defence industrial complex which includes six weapons production and three R&D facilities – the Defence Science and Technology Organisation (DESTO), the Military Vehicle Research and Development Establishment (MVRDE), and the Armament Research and Development Establishment (ARDE). It established the Margalla Electronics and Institute of Optronics in the mid-1980s to manufacture radar and night vision devices. Pakistan could utilise these facilities (if it has not already done so) and the private industry to absorb the missile technology acquired from both China and North Korea and it could enhance the indigenous capability to execute its missile programme in the future. Already, Pakistan appears to have involved private industrial firms located in Lahore, Karachi, Islamabad, Gujranwala, Sialkot and in other cities for executing the Shaheen project. However, evidence suggests that Pakistan has been facing a number difficulties in building defence technological capabilities in general. Firstly, the inter-institutional linkages between various agencies such as public R&D laboratories, private industry and public sector industry in the country do not appear to be strong and also the national level co-ordination in developing technological capabilities appears to be weak. Secondly, Pakistan does not produce basic strategic raw materials such as steel alloys and it entirely depends on foreign imports. Thirdly, the private industry in Pakistan appears to have almost no experience in manufacturing high-tech items and therefore it is unlikely to plays a major role in missile projects before going through a long learning curve (between 10 to 15 years). And finally, there appears to be "an acute shortage of scientists and design engineers" due to "the poor state of technical education in the country" (Siddiqa-Agha, 1999, pp. 353-355). Because of these problems, the success of Pakistan's missile development projects largely depends on foreign technological assistance, particularly the Chinese and the North Korean assistance. The history of Pakistan's missile programme suggests that it is highly unlikely that MTCR will prevent either China or North Korea from assisting Pakistan. Despite Pakistan's repeated statements about developing indigenous intermediate and long-range missiles, it does not appear to have the capability to develop such a missile on its own at present. It is highly unlikely to develop such a missile without active help from foreign countries, particularly either from China or North Korea.

Table 6 compares the capabilities of India and Pakistan in different areas of missile technology (airframe, propulsion, guidance, control and navigation, and weapons integration) and in different types of missile systems (theatre ballistic missiles-less than 3500 km range, ICBMs, and cruise missiles). In the area of short range ballistic missiles both countries have demonstrated significant overall capabilities, that is, they have reached production stage (at least in batches). With Chinese assistance Pakistan has built a facility in Fatehgarh (Fatehgunj), 40 km west of Islamabad, to produce M-11s (FAS Website). Using this facility, it is quite likely that Pakistan will be able to produce short and medium range versions of Shaheen in batches. It could modify and improve M-11's hardware and solid propellant motors, and employ its guidance, control, and navigation system to produce these Shaheen missiles. However, it will not be able to produce medium or intermediate range missiles without considerable foreign assistance in the area of missile guidance, propellants, and composite materials. Particularly, Pakistan is likely to face significant constraints with the intermediate range version of Shaheen and all Ghauri versions.

Table 6: Comparison of Technological Capabilities between India and Pakistan in Different Missile Systems/Technologies

Technology/Weapon System	India	Pakistan
1. Whole Weapon Systems:		
Theatre Ballistic Missiles (TBMs)	xxxx	xxx
ICBMs	xxx	xx
Cruise Missiles	xxx	xx
2. Theatre Ballistic Missiles Sub-systems		
Airframe:		
Airframe Extension to Liquid Fuelled Missiles	xxxx	xxx
Post-Boost Vehicles	xxx	xx
Propulsion:		
High-Energy Solid Fuel Motors	xxxx	xxx
Storable Liquid Propellant Engines	xxx	xxx
Strap-on-Boosters	xxxx	xxx
Guidance and Control:		
Floated Inertial Measurement Units	xxx	x
Digital Navigation and Control	xxx	xx
Post-Boost Position Realignment and Spin	xxx	x
Weapons Integration:		
Bomblets or Submunitions	xxx	xx
Transporter/Erector launchers (TELs) Manufacturing	xxx	xx
Separating Warheads	xxxx	xx
3.ICBM Sub-systems		
Airframe:		
Serial Staging	xxx	xx
Parallel Staging	xxx	xx

Strap-on Boosters	xxx	xx
Propulsion:		
High Energy Solid Propellants	xxxx	x
Large-Scale Cast Solid Grains	xxx	xx
Large Turbo-pumps for Liquid Engines	xxx	xx
Guidance and Control:		
GPS for Post-Boost Vehicles (PBV)	xxx	xx
Small Guidance Computers to fit on PBV	xxx	xx
Terminally Guided Re-entry Vehicles	xx	xx
Weapons Integration:		
Re-entry Thermal Protection Materials	xxx	xx
Post-Boost Vehicles	xxx	xx
Bobmlets	xx	xx
3. Cruise Missile Sub-systems		
Airframe:		
Control Surface Actuators	xxx	xx
High Wing Loading Aerodynamic Designs	xxx	xx
Propulsion:		
High Thrust-to-Weight Jet Engines	xx	xx
Small Turbine Engines	xxx	xx
Advanced High-Energy Fuels	xx	xx
Guidance and Control:		
Radar Maps to Support Terrcom	x	x
Digital Topographical Maps to Support GPS	xxxx	xxx
Dynamic Test Equipment	xxx	xx
Weapons Integration:		
Sprayers Adapted to Airstream	xxx	xxx
Small Nuclear Weapons	xxx	xx
4. Information Systems		
Information Communications	xxx	x
Information Exchange	xx	x
Information Processing	xxx	xx
Information Security	xxx	xx
Information Systems Management and Control	xxx	xx
Information Systems Facilities	xxx	xx

Source: The table was prepared by the author using 'Nuclear weapons foreign technology assessment summary' in US Department of Defense, *Militarily Critical Technologies List – Part II: Weapons of Mass Destruction Technologies*, 1996. But the author updated this summary taking into account various developments since 1996.

Notes:
x – Limited Capability; xx – Some Capability; xxx – Sufficient Level of Capability; xxxx – Exceeding Sufficient Level of Capability

The Ghauri versions are based on North Korean No-dong liquid propulsion system – TM27I (20% Gasoline/petrol + 80% Kerosene) with Oxidiser AK-27I (27% N_2O_4 73% HNO_3 + Iodium Inhibitor). This not a very efficient fuel system, although it is relatively less complex to handle. Furthermore, generally liquid systems involve complex liquid engines and it is difficult to handle any type of liquid fuel system. If Pakistan aims to produce Ghauri versions in numbers, it needs to master liquid propulsion technology, that is, liquid engine, liquid propellants, and associated chemicals and materials. Also, it has to develop the manufacturing capability of its industry. Considering India's experience in absorbing the Viking liquid engine technology from France, one can safely assume that Pakistan will face serious difficulties with mastering liquid propulsion technology. It may take (10 to 15) years to develop indigenous capability to build liquid engines, as they require large number of precision components. Also, they require complex test facilities. Otherwise, it has to depend on importing entire liquid engines or at least all critical components needed to build these engines and the liquid propellants from North Korea.

It is doubtful whether Pakistan has the necessary industrial capability to develop an efficient substitute for this North Korean liquid fuel system(s). Also, Pakistan appears to have very limited indigenous capabilities in the areas of guidance, control, navigation and weapons integration. Imported components and subsystems such as gyroscopes, accelerometers and on-board computers, mainly from China, have sustained its missile programme. However, it is quite possible for Pakistan to acquire more sophisticated components from Western sources to modify and improve the guidance systems acquired from China and North Korea. Outside the ballistic missile programme, Pakistan also has acquired cruise missiles -- HY-1, HY-2, FL-1, and FL-2, mainly from China (CNS Website). These are relatively old conventional weapon systems and it is questionable whether Pakistan has the capability to modify them to deliver nuclear warheads.

5. Some Conclusions:

It is clear that while India has developed an extensive nuclear infrastructure, Pakistan has developed a highly-weapon oriented, a narrowly focused and limited nuclear infrastructure. However, this does not mean India has established an overall superiority over Pakistan in nuclear technology. The experience of countries such as the US, Russia and the UK suggests that in the long-run the superiority of nuclear weapons technology of a country is likely to diminish, as nuclear technology has already matured. Therefore, a less developed rival is likely to catch up and match the capability of the stronger rival. This trend is becoming increasingly clear in the case of India and Pakistan.

Moreover, India is unlikely to produce more than a certain number of weapons, which it requires to maintain the 'minimum nuclear-deterrent posture'. For example, India is expected to maintain a force of 150 nuclear warheads by 2010 (RAND, 2001). That means we are not going to witness a kind of cold-war nuclear race between the US and the Soviet Union in the South Asia. Furthermore, while India is likely to direct its nuclear weapons against both Pakistan and China, Pakistan only needs to match India's capability. That means a determined and foreign-assisted Pakistan will sooner or later be able to match India's capability in those areas where it is behind India at present. Various developments in the 1980s and 1990s suggest that it is quite likely that Pakistan could accumulate fissile material and nuclear weapon production capabilities to achieve some kind of parity with India in the long term. It appears that India may continue to enjoy some advantages in certain areas such as thermonuclear boosting and thermonuclear second stage technologies. This is because of certain advantages associated with plutonium based weapon designs and India's relative superiority in building compact and efficient fission primary and its capability to produce materials such as tritium in significant quantity. As plutonium-based warheads are smaller, lighter, and provide higher yield than those based on uranium, Indian weapons are qualitatively superior to those of Pakistan. However, this advantage may be lost in the long-term as Pakistan is making effort to produce plutonium and also it is likely to improve the sophistication of its uranium-based weapons. Furthermore, evidence suggests that

Pakistan has been trying to establish significant indigenous capability in tritium purification. However, one area where Pakistan is likely to experience considerable problem, at least in the short and medium term, is developing compact nuclear warheads for different missile systems.

However, given the close geographic proximity between India and Pakistan, coupled with a high population density in both countries, unlike the case of Soviet Union and the US, a number of cold-war nuclear warfare strategies could become irrelevant or redundant in the context of South Asia. This included superiority in numbers, multiple warheads, high yield and high accuracy weapons for different scenarios of warfare, and so on. This does not mean that both countries will not make effort to develop more sophisticated weapons in future. However, such weapons are likely to provide increasingly 'diminished returns' and may not alter the nuclear balance between the two countries significantly in the long run.

Unlike the case of nuclear weapons, in the area of missile technology the gap between India and Pakistan appears to be more clear and significant. Over the years, India has created a wider and deeper technology base in all areas of missile technology, partly through its civil space programme. Particularly, India has established strong indigenous capabilities by the late 1990s in many critical areas such solid and liquid propellant systems, guidance, control and navigation systems, advanced materials, space electronics, and hardware fabrication. While it is quite likely that Pakistan will be able to demonstrate launching of test flights of next generation Ghauri and Shaheen missiles with foreign assistance, it is unlikely that it will be able to produce and deploy them in numbers in the short-term. Unless it is able to procure most of the critical subsystems from China and North Korea, Pakistan will not be able to test launch Ghauri III and Shaheen II (IRBMs). This is particularly the case with Ghauri III, as it is a two-stage liquid system that would require a number of new subsystems and components or improved/modified subsystems and components employed by Ghauri I and II. It is quite unlikely that Pakistan has acquired the capability to develop a new liquid engine or modified/improved engine of Ghauri I in a short period (since it tested the single liquid stage Ghauri II in 1999). Again, Pakistan does not appear to have the capability to develop an ICBM, despite its public announcements. Even if it does have such capability, it may not devote its resources on developing ICBMs, because it will be politically and strategically unjustifiable. On the other hand, India has capabilities to develop an ICBM within a short period. It has world-class capabilities in solid propulsion systems and a high level of capability in liquid systems. It has established a strong industrial capacity to implement its missile programme, without seriously depending on foreign imports. In short, India currently enjoys superiority in a number of areas of missile technology over Pakistan and it is likely to continue for quite some time because of the rate of technological change taking place in this area. This enables India to maintain a degree of superiority over Pakistan at least in the short and medium terms. Whether Pakistan will be able to close this gap in the near future will largely depend on the degree of foreign assistance it can manage to receive particularly from China and North Korea.

If Pakistan decides to compete with India by developing capabilities to produce long and intermediate range ballistic missiles indigenously, it will not be able to succeed without committing huge resources (both financial and human resources) over a long period (between 15-20 years) and without strong foreign assistance. Also, its industry will not be in a position to develop and produce these missile systems in numbers, before it has gone through a long learning curve (at least 10 to 15 years). Then, there is the question of keeping up with technological change in missile technology. It is unlikely that Pakistan will be able to keep pace with the rate of technological change in missile technology without strong foreign assistance. On the other hand, it quite likely that Pakistan may ignore 'catching up' with the technological change. Instead, it may decide first to acquire missile systems and technologies (whether at the frontier level or old generation) in different range categories and then standardise and optimise them through incremental improvements and modifications. In other words, it is quite likely that Pakistan may decide to create and maintain a missile force in all range categories (except ICBM) without giving much importance to their technological sophistication.

To recapitulate, although a number of nuclear and missile developments suggest that India and Pakistan are pursuing a strategic arms race, it is unlikely to be intensified to a higher degree in the medium and long-term when they would increasingly become mature. While it is increasingly clear that the nuclear build-up between India and Pakistan cannot be stopped or eliminated, it can be contained and managed to a less dangerous level.

Despite nuclear weapons deployment, recent arms deals suggest that the importance of conventional weapons and forces are not going to be reduced in both India and Pakistan. This means both countries would have to maintain sophisticated conventional forces along with nuclear weapons deployment. This entails finding extra resources for nuclear weapons rather than diverting resources from convention forces by reducing their level. This demand for further resources is likely to be major constraint on nuclear and missile race in the medium and long-term.

The impact of nuclear and missile developments in South Asia on regional and global security can be very significant. Already India's nuclear doctrine has raised concerns in China and India's announcement about testing Agni III that will have the capability to strike deep into China is likely to have significant impact on Chinese strategic policies in the medium and long-term. The developments in South Asia also have implications for the non-proliferation regimes in general. The non-involvement of Pakistan and India in the existing non-proliferation regimes, particularly the NPT and MTCR, makes them significantly less effective. First, it is clear that Pakistan's nuclear and missile programmes are linked to and supported by China and North Korea and the latter in particular is linked to similar programmes in other countries such as Iran. This clearly shows how non-proliferation regimes could be circumvented through horizontal linkages between second-tier technology suppliers / recipients. Secondly, it is likely that countries such as North Korea and Iran are encouraged to pursue their nuclear and missile programmes more vigorously, after seeing the developments in South Asia. Therefore, it is important to develop new non-proliferation mechanisms to bring on-board both India and Pakistan. Finally, the nuclear and missile developments in South Asia makes it increasingly clear that the permanent five nuclear powers must take initiatives to achieve total nuclear disarmament at least within a distant timeframe, if they are very serious about non-proliferation and global security.

Selected References:

Albright, David (2000), *India's and Pakistan's Fissile Material and Nuclear Weapons Inventories, end of 1999*, Institute for Science and International Security, October 11. See <http://www.isis-online.org/publications/southasia/stocks1000.html>

Albright, David and Hibbs, Mark (1992), "Pakistan's Bomb: Out of the Closet," *Bulletin of Atomic Scientists*, January.

Bermudez, Joseph S. (1999), *A History of Ballistic Missile Development in the DPRK*, Occasional Paper No. 2, Center for Nonproliferation Studies, Monterey Institute of International Studies, Monterey, CA.

Center for Nonproliferation Studies (CNS), Monterey Institute of International Studies, Monterey, CA. <http://cns.miis.edu/research/india/china/msaspos.htm>

Cordesman, Anthony H. (2002), *The India-Pakistan Military Balance*, Center for Strategic and International Studies, Washington DC.

Federation of American Scientists (FAS), <http://www.fas.org/nuke/guide/pakistan/nuke/index.html>

Nayyar, A.H., Toor, A.H. and Mian, Zia (1997), "Fissile Material Production Potential in South Asia," *Science and Global Security*, vol. 6.

RAND Research Brief (2001), *India's Emerging Nuclear Posture*, RB-63 (2001). <http://www.rand.org/publications/RB/RB63/

Siddiqa-Agha, Ayesha (1999), "Pakistan's Defense Industry: An Effort Towards Self-Reliance," *Defence and Peace Economics*, vol. 10, no. 4, pp. 347-359.

US Department of Defense (1996), *Militarily Critical Technologies—Part II: Weapons of Mass Destruction Technologies*, Washington D.C.

Wick, Raymond V., Hendricks, Gerald K., Lewis, L. Kirk, and Jorstad, Norman. D (1994), *Executive Report: Space Systems Technology Working Group*, IDA Document D-1519 (Revised), Institute for Defense Analysis, Washington, D.C.